

SEPARATION OF OIL AND WATER BY USING COCONUT COIR

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ABSTRACT

The aims for this study are to examine the emulsion stability and to evaluate the effectiveness of using coconut coir in the separation of oil and water (emulsion). Crude oil and distilled water were used as the raw materials. To complete the objective, there are three main (3) parts of experiment need to be done. The first part was the pre-treatment of the coconut coir. In this part, the required particle sizes of the coir which varied between 630 μm to 2 mm were determined and also had been modified, weighing and packaging. While in the second part the formation and stabilization of the oil-in-water (O/W) emulsion was examined. The O/W ratios were varied from 50-75:50-25 and during the stability part the emulsion was verified by visually observes on separation layer for each of the samples of emulsion. As for the emulsifier, Tween 20 at different concentration 1%, 3% and 5% of total volume was used in formation of O/W emulsion. Last but not least, the last part studied the separation of oil and water by using coconut coir. The optimum condition of O/W emulsion is discovered by the correlation between the emulsifier concentrations, and oil-water ratio. Here, the effectiveness of prepared coconut coir is analyzed in order to adsorbed the raw crude oil, and water by considering the effect of size particles and the modification of the coconut coir. Then, the amount of oil and water being adsorbed and recover from the coconut coir are weighed to see the efficiency of the coconut coir. The most stable of O/W emulsion was found at 5% of emulsifier concentration at 75-25% of oil-water ratio. The adsorption of oil was better at 630 μm particle size of unmodified coir. Therefore, the effectiveness of the coconut coir in order to separate the most stable emulsion into oil and water would be required.

Key words: O/W emulsion stabilization, Coconut coir, Tween 20, Separation

ABSTRAK

Kajian ini telah diadakan bagi mengkaji pembentukan kestabilan emulsi dan menilai tahap keberkesanan penggunaan sabut kelapa dalam proses pengasingan minyak dan air (emulsi). Minyak mentah dan air suling digunakan dalam menjayakan kajian ini. Kajian ini terbahagi kepada tiga (3) bahagian yang utama. Bahagian yang pertama adalah mengenai pra-rawatan yang dilakukan terhadap sabut kelapa. Dalam bahagian ini, saiz sabut kelapa iaitu 630 μm dan 2 mm ditentukan, ditimbang, dan diubahsuai. Manakala, dalam bahagian yang kedua (2) pula pembentukan dan kestabilan emulsi minyak didalam air dijalankan. Nisbah minyak-air dilakukan dalam mengikut nisbah yang berbeza-beza daripada 50-75:50-25 dan dalam kajian mengenai kestabilan emulsi, ianya dijalankan dengan memerhatikan lapisan pemisahan air pada setiap sampel. Bagi ejen pengemulsi iaitu *Tween 20* digunakan pada kepekatan yang berbeza iaitu pada 1%, 3% dan 5% dalam proses penyediaan emulsi ini. Pada bahagian terakhir (3), sabut kelapa yang diubah suai dan tidak diubahsuai digunakan bagi menganalisis kebolehan sabut kelapa untuk menjerap minyak mentah. Didapati bahawa keadaan optima bagi pembentukan dan kestabilan emulsi telah ditemui dengan mengaitkan kepekatan bahan pengemulsi dengan nisbah minyak-air. Manakala, keberkesanan abut kelapa dianalisis dalam usaha untuk mejerap minyak mentah dan air dengan mengambil kira aiz, dan pengubahsuaian yang dilakukan kepada abut kelapa. Keputusan bagi emulsi yang paling stabil adalah apabila kepekatan pengemulsi ialah 5 % dan nisbah minyak-air pada 75-25%. Penjerapan minyak yang optima didapati lebih berkesan pada saiz 630 μm bagi sabut kelapa yang tidak mengalami penubahsuaian. Maka, keberkesanan sabut kelapa dalam memisahkan emulsi yang paling stabil kepada minyak dan air adalah berkesan.

CHAPTER 1

INTRODUCTION

1.1 Background of Research Study

Bradley et al. (2006) was investigate that coconut palm tree can also be known as *Cocos Nucifera* trees which grow abundantly along the coast line of countries within 15° of the equator. They are grown well in saline soil, sandy and tropical climate. Besides, a healthy coconut tree will produce about 120 watermelon-sized husks per year, each with a coconut embedded inside. Besides, based on the project that has been done by the School of Education, University of Queensland Australia (2010), it stated that probably coconuts grew originally in South Asia, Malaysia and Polynesia.

Moreover, the coconut provides a nutritious source of juice, meat, oil, and also milk that has fed and nourished populations around the world for generations. On the other hand, many populace of island think coconut is a staple in the diet and provides the majority of the food eaten. Almost one third of the world's population depends on coconut to some degree for their economy and their food. Amongst these cultures the coconut has a long and respected history (Coconut research centre, 2010).

Coconut is highly nutritious and rich in vitamins, minerals, and fibre. It is classified as a "functional food" because it gives many health benefits beyond its nutritional content. Coconut oil is of unusual interest because it possesses healing properties far beyond that of any other dietary oil and is extensively used in traditional medicine among Asian and Pacific populations. Pacific Islanders consider coconut oil to be the cure for all illness. The coconut palm is so well valued by them as both a source of medicine and food that it is called "The Tree of Life." Only recently has current medical science unlocked the secrets of coconut's amazing healing powers (Coconut Research Centre, 2010).

1.2 Problem Statement

In Malaysia, the coconut tree is a plant that has many uses in all aspects of life. All parts such as coconut fruits, stems, and leaves have its own uses. After use or taken its content, the left part is called as waste materials. For examples, coconut husk, coir, shell and others.

The effort to utilize these waste materials in Malaysia is still low. The disposal of these materials is expensive and may lead to environmental problem (Zuim et al., 2011). Besides, many of these wastes has been thrown away and burnt. This phenomenon will give bad effect to the environment.

So, in order to reduce environmental problems, maximum recycling of the wastes should be established. This can directly increase the profitability of the agriculture industry and thus can help to reduce the environmental pollution. In addition, coconut coir is one of the main waste materials that can pollute the environment. Therefore, new alternative need to be discover in order to reduce the environmental problems.

Recently, there is an alternative application for coir fibre to be used in composite materials had been studied (Ezekiel et al., 2010; Tran et al., 2011). Before this the coir fibre from the husk is used for the production of non-food products such as yarns and ropes, mats, padding of mattresses and brushes This had been done in Southern India and Sri Lanka which already have a long standing tradition and is the major production areas of a wide range of diversified coir products (Rodríguez et al., 2011).

1.3 Objectives of Study

At the end of this study, it is necessary

- i. To examine the emulsion stability using emulsifier in different concentration at different volume ratio of oil-in-water emulsion
- ii. To evaluate the effectiveness usage of coconut coir in separation of oil and water

1.4 Scopes of Study

There are important task to be carried out in order to achieve the objectives of this study. The important scopes that have been identified for this research are;

- Determine the optimum condition for oil in water emulsion stability by;
 - i. Test the effectiveness of emulsifier concentration on emulsions stability
 - a. 1 %
 - b. 3 %
 - c. 5%
 - ii. Investigate the efficiency of different volume ratio of oil in water emulsion in stabilizing emulsions
 - a. 50-50%
 - b. 65-35%
 - c. 75-25%
- Determine the optimum condition for coconut coir for separation of oil and water by;

- i. Analyse the efficiency of modification coconut coir in order to adsorb oil
 - a. Modified with sulphuric acid
 - b. Unmodified
- ii. Determine the volume adsorbed and recover by the different particle size of coconut coir
 - a. 2 mm
 - b. 630 μm

1.5 Rationale and Significance

- i. Coconut coir is the cheapest raw material that can be use.
- ii. Coconut coir is easy to get and environmental friendly.
- iii. It will lead to maximise the uses of coconut coir widely in Malaysia.
- iv. It will boost up the coconut supplier or industries earnings as well as to increase the Malaysia's economy.
- v. The important thing is reduce the contaminations or in other word save the earth.
- vi. Lastly, able to increase the living standards and income of the local workers in Malaysia.

CHAPTER 2

LITERATURE REVIEW

2.1 Coconut

The scientific name for the coconut tree is *Cocos nucifera* L.(Abdul Khalil et al., 2006; Adeyi & Oladayo, 2010; Asasutjarit et al., 2007; Bradley et al., 2006; Defoirdt et al., 2010; Koschek et al., 2007; Rodríguez et al., 2011; Tran et al., 2011;Young, 1983).

Researchers concede that the coconuts are grown extensively in coastal areas of tropical countries (Bradley et al., 2006; van Dam et al., 2004), for example with consider to the implantation of coconut trees in Sri Lanka (Rodríguez et al., 2011; van Dam et al., 2004), Malaysia (Abdul Khalil et al, 2006), Philippine (van Dam et al., 2006), Vietnam (Tran et al., 2011), Brazil (Koschek et al., 2007; Zuim et al.,2011) and others.

In Malaysia, one of the most important crops is coconut palm (*Cocosnucifera* L.). Besides, statistics showed that total production of coconut palm based on states are increased from 512,699 in 2006 to 555,120 metric ton in 2008 (MOA,2009).

There are varieties types of coconut in Malaysia which includes Malayan Tall, MAWA, MATAG, Malayan short and Wangi. Perak, Johor, Selangor, Sarawak and Sabah are the top producer of coconut (MOA, 2009).

2.1.1 Coconut coir

The coir fibre is obtained from coconut husk and because of its high content of lignin; it is also one of the hardest natural fibres. Similarly, Praveen et al. (2008) acknowledge that coir is hard and though organic fibre has been extracted from the husk of the coconut.

In addition to that, van Dam et al. (2006) also report that fibre were manually extracted from the husk and separated from the pith. Figure 2.1 shows the parts inside of the coconut. It consists of 4 parts which are husk, skin, shell and copra.

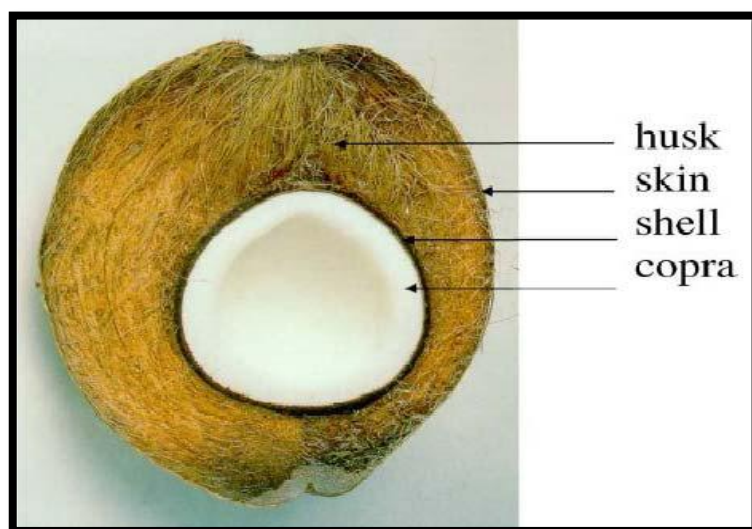


Figure 2.1: Coconut and husk

Source: (Bradley et al., 2006)

2.1.2 Chemical composition in coconut coir

In order to proceed for this study, one needs to know the chemical composition of the fibre. From van Dam et al. (2006) researched its state that chemical compositions of coir fibre of different varieties are similar. Table 2.1 shows that each chemical composition (lignin, hemi-cellulose, alpha cellulose, and extractive) has the similar amount in percent for each varieties of coconut. Besides, many researchers agree that coconut contain high content of lignin (Abdul Khalil et al., 2006; Adeyi & Oladayo, 2010).

Table 2.1: Chemical composition of coir fibre and pith of different coconut varieties

variety	hot water extractive (%)	alpha cellulose (%)	hemi-cellulose (%)	uronic acid (%)	acid insoluble lignin(%)	acid soluble lignin (%)	total lignin (%)	ash (%)
CATD Fiber	2.3 (0.1)	35.1 (0.3)	16.8 (0.3)	4.6 (1)	32.7 (1.1)	1.0(0.3)	33.6 (0.9)	2.6 (0.4)
CATD Pith	9.8	20.8	15.7	6.6	42.4	1	43.5	6.1
AGAT Fiber	2.9 (0.0)	35.1 (0.8)	17.4 (0.1)	3.8 (1)	34.6 (0.1)	1.4 (0.1)	36 (0.1)	3 (0.3)
AGAT Pith	15	21.1	13.4	5.5	44.6	1.5	46.1	7.9
TAGT Fiber	2 (0.1)	34.9 (0.5)	17.6 (0.8)	4.9 (0)	34.5 (0.2)	1.3(0.1)	35.8 (0.1)	1.6 (0.2)
TAGT Pith	11.9	22.7	16.6	5.7	43.7	1.3	44.9	3.5
LAGT Fiber	2.1 (0.2)	35.2 (0.3)	17.6 (0.5)	4.7 (2)	34.6 (0.5)	1.3(0.1)	35.7 (0.8)	2.7 (0.3)
LAGT Pith	12.6	20	15.5	5.5	45.7	1.2	46.9	7.2
RIT Fiber	2 (0.4)	33.3 (0.2)	18 (0.3)	4.8 (2)	35.4 (0.3)	1.3(0.1)	36.6 (0.1)	2.3 (0)
RIT Pith	12.6	20.5	15	5.3	45.9	1.4	47.3	5.5
BAYT Fiber	1.8 (0.5)	35.5	17.3 (0.5)	3.5 (2)	34.9 (0.6)	1.2 (0.1)	35.9 (0.8)	2.5 (0.1)
BAYT Pith	10.9	23.1	12.3	66	44.2	1	45.2	6.6

Source: (van Dam et al., 2006)

2.1.3 Physical properties

2.1.3.1 Colour

There are too many varieties color of coconut which can be from pale yellow to dark brown. Neutrally, its depends on the varieties of coconuts, maturity, time lapsing between husking and retting, quality of water used for retting and the duration of retting (Jayasekara et al., 2010)

2.1.3.2 Impurities

Impurities' degree in mattress and mixed coir is based on the predetermined contract between the buyer and the supplier. Other than coir, including husk and this considered as an impurity in coir (Jayasekara et al., 2010).

2.1.3.3 Texture

It is solid, resilient, spongy and elastic. Resilience showed the amount of energy kept up in a body when one unit volume is stressed or compressed. Furthermore, after releasing the compression force, it is measured as a percentage deviation from the original volume (Jayasekara et al., 2010).

2.2 Emulsification

It is a process where two immiscible liquid that are normally mixed, one liquid which are discontinuous, dispersed or internal phase becoming dispersed in form of small droplets or globule in the other liquid which are continuous, dispersing or external phase (Abdurahman et al., 2010; SitiNurul Huda, 2009)

2.2.1 Type of Emulsion

Referring to Siti Nurul Huda (2009) research, in most emulsions, one of the liquids is in aqueous while the other is hydrocarbon and usually comes in form of oil. There are two types of emulsion that can distinguish by determined which kind of liquid form the continuous phase (external phase). This can be shown in Figure 2.2 below, they are;

- Water-in-oil (W/O) for water droplets dispersed in oil.
- Oil-in-water (O/W) for oil droplets dispersed in water.

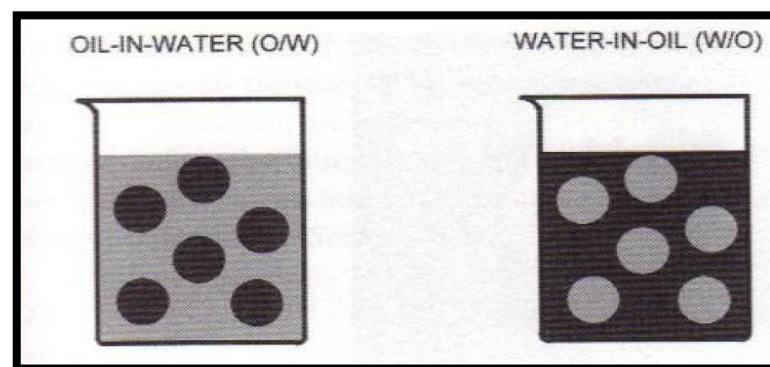


Figure 2.2: Oil-in-water (O/W) and water-in-oil emulsion (W/O)

Source: (SitiNurul Huda, 2009)

Factors of the type of emulsion formed are;

- a. Type of emulsifying agent used
- b. Relative proportions of the phases
- c. Method of preparation of the emulsion

2.2.2 Interfacial Tension

Interfacial tensions occur when energy increased from an imbalance in the cohesive forces of the two liquids to form the smallest possible interfacial area. The interfacial tension for oil and water are high and that is why these two fluids cannot be mix. The higher of the interfacial tension make the emulsion become less stable and therefore decrease the ability to form an emulsion.

2.2.3 Emulsifying agent (emulsifier)

Emulsifier is added to the emulsion solution in order to stabilize the water and the oil. This emulsifier is use widely in our daily life. For example are detergent creams and lotions. The emulsifier used will decreased the interfacial tension between the oil and water in order to form an emulsion. The stability of an emulsion depends on the factors of emulsion formed discuss in section 2.2.1.

Types of emulsifying agents are;

- a. Naturally occurring material such as protein and phospholipids.
- b. Synthetic materials like ester of glycerol, propylene glycol, sorbitan ester of fatty acids and cellulose ethers.
- c. Kindly divided solids such as bentonite and carbon black.

2.3 Demulsification

Demulsification is a reverse from emulsification process. Meaning that, it is a process of oil and water separation from emulsion. But because of the demulsification mechanism of the demulsifier is quite complicated therefore not all of crude oil emulsion can break by the demulsifier. Typical demulsification techniques include electrical, chemical, thermal, mechanical or acoustic method (Abdurrahman et al., 2010; SitiNurul Huda, 2009)

2.3.1 Demulsifying agent (demulsifier)

Both emulsifier and demulsifier act as the surface-active agent (surfactant). The difference is the function of itself. Demulsifier is added to the emulsion solution and act as separator which is to separate the oil and water. (Abdurrahman et al., 2010)

The essential needs on demulsifiers are the abilities to have one or more of the following behaviours (“Demulsification in petroleum recovery”);

- a. The oil or water interface must be strong with the capability to destabilize the protective film around the droplet and/or to adjust the contact angle of the solids which may be part of the interfacial film;
- b. Ability to flocculate the droplets;
- c. Ability to uphold coalescence by opening path for water’s natural attraction to water; and
- d. Promotion of film drainage and thinning of the interdroplet lamella by raised compressibility and put changes to the interfacial viscosity.

2.4 Characterization

2.4.1 Temperature

Liebold et al. (1975) said that the temperature at which certain crude oils containing higher hydrocarbon chains are demulsified are from 40°C to 80°C. In common, temperature of between 50°C and 80°C are maintained and these give the optimum results.

2.4.2 Particle size

Referring to Nduka et al. (2008), the particles size is one of the major determining factors. The particle size enhance the mopping ability as follow – carbonized 325µm > uncarbonized 325 µm> carbonized 625µm> uncarbonized 625µm. Therefore the smaller the size particle the more it will adsorb the oil. Thus, for this study the particle size that will be used are gross fibre and fine fibre.

2.4.3 Rheological models

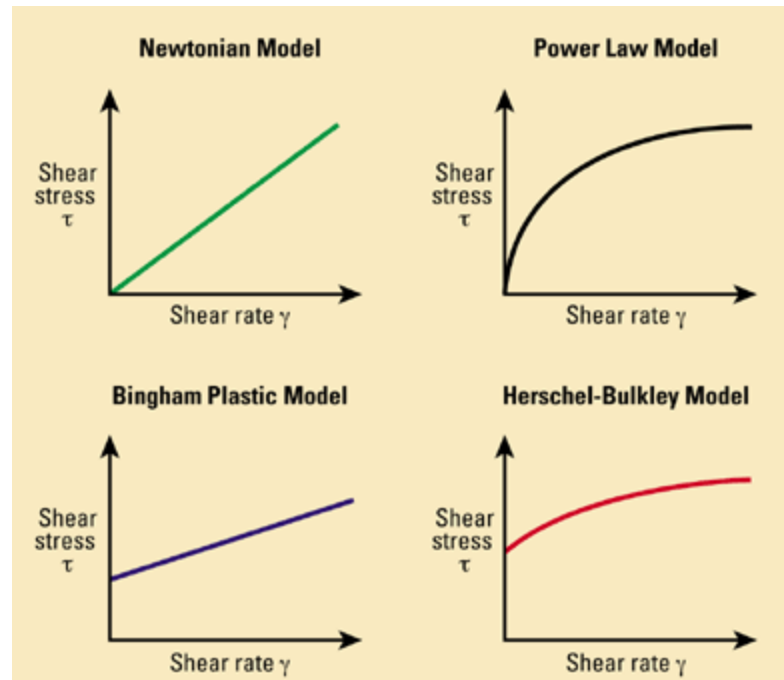


Figure 2.3: X-Y plots of rheological models

Source: Schlumberger, 2011

Fluids are described as Newtonian or non-Newtonian depending on their response to shearing. Shear stress of a Newtonian fluid (upper left) is proportional to the shear rate. Most drilling mud are non-Newtonian fluids, with viscosity decreasing as shear rate increases, and correspond more closely to one of the other three models shown (Schlumberger, 2011).

2.5 Oil-water separation

From Siti Nuurul Huda (2009) study, separation process in chemistry and chemical engineering is used to transform a mixture of substances into two or more different products. These separated products could be differing in terms of physical or chemical properties.

Oil can exist in water in several ways;

- a. Free oil – created by oil droplets with a diameter go over for about 30 microns. It increases rapidly to the water surface when given a sufficient quiescent settling period (Surthesan, S. S., 1999).
- b. Mechanical dispersions – fine oil droplets allocations ranging in size from less than 1 micron to 30 microns and having stability because of electrical charges and other forces, but due to the presence of surface active materials (Surthesan, S. S., 1999).
- c. Chemical emulsions – the oil droplets distribution is similar to mechanical dispersion, but which have additional stability due to chemical, the surface active agents present at the oil and water interface may create an interaction (Surthesan, S. S., 1999).
- d. Dissolved oil – dissolved in a chemical sense; the removal by normal physical means is impossible (Surthesan, S. S., 1999).

- e. Oil that holds to the surface of particulate materials – known as oil wet solids (Surthesan, S. S., 1999).

2.5.1 Types of separation process

There are many ways to separate a solution into two or more different products such as;

- a. Adsorption
- b. Crystallization
- c. Distillation
- d. Drying
- e. Evaporation
- f. Extraction
- g. Filtration
- h. Centrifugation
- i. Sedimentations
- j. Precipitations and many more.

CHAPTER 3

METHODOLOGY

3.1 Introduction

This chapter describes the materials, apparatus, equipment and experimental method used in this study. The experiment was divided into three main (3) parts; the first part was the pre-treatment of the coconut coir, while the second part examined the formation and stabilization of the oil-in-water emulsion and the last part studied the separation of oil and water by using coconut coir.

3.2 Materials and Apparatus

1. Brookfield Rotational Digital Viscometer Model LV/DV-III (equipped with a water bath thermostat, and a spindle set)
2. Grinder
3. Vibratory Sieve-shaker

4. Stirrer (three-blade propeller)
5. Apparatus (500ml/250ml/50ml glass beaker, 100ml/10ml measuring cylinder, 1000ml conical flask, 100-1000 μ m micropipette, aluminum foil, filter paper, cotton fabric)
6. 10L light crude oil, Bintulu crude oil
7. Surfactant: Tween 20
8. Coconut coir
9. Sulphuric acid (H_2SO_4)

3.3 Sample preparation and Experimental procedures

3.3.1 Pre-treatment method

3.3.1.1 Grinding

The purpose of this process is to grind the raw coconut coir into a medium/small particle size of fibre. This equipment is known as grinder. It's only suitable for a fibre material such as coconut coir, sugar cane, empty fruit bunch and etc. For safety purpose, the grinding must be operating with laboratory assistant (J.P) existence. In Figure 3.1 below, its shows the step on how to operate the grinder.

